

1                                   **IMPROVED THERMOSTATIC MIXING VALVE**

2  
3                                   Cross-Reference to Related Applications

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5                                   This application claims the benefit of U.S.  
6                                   Provisional Patent Application Serial Nos. 60/099,090 and  
7                                   60/099,444, filed September 4, 1998 and September 8, 1998,  
8                                   respectively.

9  
10                                  Background of the Invention

11  
12                                  1.   Field of the Invention

13                                  The present invention generally relates to mixing  
14                                  valves, and more particularly to a thermostatic mixing valve  
15                                  having an improved mixing chamber and a diffuser for  
16                                  facilitating the mixing of a hot fluid and a cold fluid.

17  
18                                  2.   Discussion of the Related Art

19                                  Thermostatic mixing valves are commonly used in  
20                                  plumbing systems. They typically take hot water from a water  
21                                  heater and cold water as supplied to the building by the  
22                                  water company and blend the hot and cold water to a desired  
23                                  intermediate temperature. The blended (or mixed) water is  
24                                  then fed into the hot water supply piping of the building.  
25                                  For a number of reasons it is generally desirable to have  
26                                  the hot water generator produce water hotter than that  
27                                  desired at the plumbing fixture, thus the need for a mixing  
28                                  valve. The valves are so constructed that the temperature of  
29                                  the mixed water remains constant, or nearly constant,

1 regardless of the actual hot and cold water temperatures and  
2 regardless of the flow rate.

3 The prior art valves work fairly well under  
4 steady state conditions, i.e., steady pressures and  
5 temperatures at all points and parts along the plumbing  
6 system. However, when steady state conditions are suddenly  
7 disturbed, such as, for example, when a nearby flushometer  
8 is being activated, large fluctuations in the mix water  
9 temperature can occur. Changes as much as  $\pm 15^{\circ}$  F have been  
10 observed.

11 A prior art thermostatic valve is shown in Fig 1.  
12 The valve 10 consists of six major components: a body 12, a  
13 thermal actuator 14, a spool 16, a biasing spring 18, a body  
14 cover 20 and a temperature selection device 22.

15 The body 12 incorporates a hot port, made up of  
16 an external hot port 24a and an internal hot port 24b, a  
17 cold port, made up of an external cold port 26a and an  
18 internal cold port 26b, and a mix port 28. Body 12 also  
19 includes a hot annular groove 56 and a cold annular  
20 groove 58. The body 12 and is typically formed from forged  
21 or cast metal. The thermal actuator 14 is a device which  
22 monitors the temperature of water flowing past it and  
23 converts temperature changes into an axial motion via a  
24 piston 30. Thermal actuators are made by a number of  
25 manufactures, including Vernet. The operating principle of  
26 thermal actuators, also called thermal elements, is known in  
27 the art and will not be described in detail. Generally, a  
28 thermal expansion material (not shown) which is located  
29 within cup 32 of thermal actuator 14 expands and contracts

1 in response to increases and decreases, respectively, in the  
2 temperature of the fluid which flows past the cup 32. When  
3 the thermal expansion material expands, it pushes actuator  
4 piston 30 of thermal actuator 14 outwardly. When the  
5 thermal expansion material contracts, actuator piston 30  
6 recedes into the thermal actuator 14. A mixing chamber 60  
7 is formed between the bottom of spool 16 and an annular  
8 ring 62, which is part of cup 32 of thermal actuator 14.

9 The spool 16 is located between surface A of the  
10 body 12 and surface B of the body cover 20. The distance  
11 between surface A of the body 12 and surface B of the body  
12 cover 20 is greater than the length  $\ell$  of spool 16. The  
13 difference in the distance between surface A of body 12 and  
14 surface B of body cover 20 and the spool length  $\ell$  is  
15 referred to as the spool stroke, which is the distance that  
16 the spool 16 can travel between the surface A of body 12  
17 and surface B of body cover 20. Spool 16 includes an  
18 annular cold water chamber 34 and is supported and  
19 frictionally engaged within body 12 by O-ring seal 36.

20 Thermal actuator 14 is threadably coupled to  
21 spool 16 within a central hub 44 of spool 16, such that  
22 actuator piston 30 is disposed within central hub 44 and  
23 such that the actuator piston 30 travels in a direction  
24 along the longitudinal axis 46 of the spool 16.

25 Temperature selection device 22 includes a  
26 spindle 40 which is threadably coupled to a handwheel 42.  
27 Spindle 40 includes a head 52 disposed within central hub 44  
28 of spool 16 such that it is in direct contact with actuator  
29 piston 30. Spindle 40 is frictionally mounted within

1 central hub 44 by an O-ring seal 54. - Bias spring 18 is  
2 engaged at one end against an internal ridge 50 of body 12  
3 and at the opposite end against annular ring 62 of thermal  
4 actuator 14, and biases actuator piston 30 of thermal  
5 actuator 14 against head 52 and spool 16 toward surface B of  
6 body cover 20. Temperature selection device 22 is operable  
7 by turning handwheel 42 in a counterclockwise direction to  
8 urge spindle 40 against actuator piston 30, thereby forcing  
9 spool 16 away from surface B of body cover 20 and toward  
10 surface A of body 12. Conversely, handwheel 42 is turned in  
11 a clockwise direction to draw spindle 40 away from actuator  
12 piston 30, thereby allowing the bias force provided by bias  
13 spring 18 to push spool 16 toward surface B of body cover 20  
14 and away from surface A of body 12. As further described  
15 below, this adjustment of the distance between spool 16 and  
16 surfaces A and B changes the ratio between the hot and cold  
17 water which is being mixed by the valve 10. A typical range  
18 is 80°F-120°F but almost any range required can be provided.

19 The operation of valve 10 will now be described.  
20 Hot water enters the body 12 through the external hot  
21 port 24a, as shown by dashed lines 80, fills the hot annular  
22 distribution groove 56, and then flows radially inward  
23 through the internal hot port 24b into the mixing  
24 chamber 60. Cold water enters the body 12 through the  
25 external cold port 26a, as shown by dotted dashed lines 82,  
26 fills the cold annular distribution groove 58, flows  
27 radially inward through the internal cold port 26b into the  
28 annular cold water chamber 34 and then flows through a  
29 series of holes located in the spool 16 into the mixing

1 chamber 60. Hot and cold water blend in the mixing  
2 chamber 60 to provide water having a temperature somewhere  
3 between the hot water and cold water temperatures. This  
4 mixed water, shown by solid lines 84, is discharged from  
5 valve 10 through mix port 28.

6 If the temperature of the cold water supply  
7 decreases such that the thermal expansion material within  
8 cup 32 of thermal actuator expands, actuator piston 30 is  
9 pushed outwardly from thermal actuator 14 against head 52 of  
10 spindle 40. This causes thermal actuator 14 to pull  
11 spool 16 away from surface B of body cover 20 and toward  
12 surface A of body 12. As spool 16 is pulled toward  
13 surface A, the width of the internal hot port 24b decreases,  
14 thereby decreasing the amount of hot water which is allowed  
15 to pass into mixing chamber 60. At the same time, as  
16 spool 16 is pulled away from surface B, the width of the  
17 internal cold port 26b increases, thereby increasing the  
18 amount of cold water which is allowed to pass through  
19 annular cold water chamber 34 and into mixing chamber 60.  
20 The resulting mix of water discharged through mix port 28  
21 therefore has a temperature which is closer to the desired  
22 temperature set by the temperature selection device. As the  
23 temperature of the mixed water decreases, the thermal  
24 expansion material contracts, causing actuator piston 30 to  
25 recede into the thermal actuator. Bias spring 18 then  
26 forces thermal actuator 14 and spool 16 toward surface B,  
27 thereby allowing internal hot port 24b and internal cold  
28 port 26b to return to their steady-state positions.

1                    -- If the temperature of the hot water supply  
2       decreases, the opposite action occurs in thermal actuator 14  
3       and, as piston 30 retracts into the thermal actuator 14,  
4       spool 16 is pushed toward surface B by bias spring 18. This  
5       causes the width of the internal hot port 24b to increase,  
6       thereby increasing the amount of hot water which is allowed  
7       to pass into mixing chamber 60. At the same time, as  
8       spool 16 is pushed toward surface B, the width of the  
9       internal cold port 26b decreases, thereby decreasing the  
10      amount of cold water which is allowed to pass through  
11      annular cold water chamber 34 and into mixing chamber 60.  
12      The resulting mix of water discharged through mix port 28  
13      therefore has a temperature which is closer to the desired  
14      temperature set by the temperature selection device.

15                    As described above, the amount of actuator  
16      piston extension is a function of the temperature of the  
17      element. This fact is exploited to provide the temperature  
18      control for the mixing valve 10. The spool 16 will settle in  
19      at the exact axial position which delivers the mix water  
20      temperature that is consistent with the actuator piston 30  
21      extension of that temperature. Should a disturbance occur,  
22      such as for example, an increase in the hot water supply  
23      temperature, the mix temperature is momentarily also  
24      increased. The thermal actuator 14 reacts to this increase  
25      of mix temperature with a corresponding increase in the  
26      extension of actuator piston 30. Since thermal actuator 14  
27      and spool 16 are biased against each other, the spool 16 is  
28      driven downward, thus decreasing the size of the internal  
29      hot port 24b while simultaneously increasing the size of the

1 internal cold port 26b, thus restoring the desired mix  
2 temperature. As is readily apparent, when the axial  
3 position of the adjustment spindle 40 is changed (when  
4 turning hand wheel 42, spindle 40 moves up or down in the  
5 spindle thread 70) the resulting mix temperature also  
6 changes. The total achievable range is determined by the  
7 specific characteristics of the thermal actuator 14.

8 There are several shortcomings of the mixing  
9 valve 10 described above. First, the mixing chamber 60 is  
10 too small to allow the hot and cold water to thoroughly mix  
11 before passing by the cup 32 of the thermal actuator 14.  
12 This can cause wide ranges of temperatures which are flowing  
13 across thermal actuator 14, which can result in inaccurate  
14 reactions of the thermal actuator 14. This causes the  
15 actuator to read and respond to a false mix temperature.  
16 When, some distance downstream of the valve, the water does  
17 become thoroughly mixed, its temperature may be  
18 significantly different from that which the thermal  
19 actuator 14 sensed.

20 Another shortcoming is the positioning of the  
21 bias spring 18 of the mixing valve 10. When the mixed water  
22 flows from the mixing chamber 60 toward the cup 32, it is  
23 forced through the coils of the bias spring 18 on its way  
24 to mix port 28, as shown by solid lines 84. Since some of  
25 the water is directed away from the cup 32 by the coils of  
26 the bias spring 18, a less accurate reading of the water  
27 temperature may be taken by the thermal actuator.

1 Furthermore, the flow of water through the coils  
2 of bias spring 18 can cause the spring to vibrate, thereby  
3 creating a noise which is objectionable.

4 What is needed then is a thermostatic mixing  
5 valve which facilitates the mixing of the cold and hot water  
6 before the water passes over the cup of the thermal  
7 actuator, thus allowing the thermal actuator to more  
8 accurately react to the temperature of the mixture, thus  
9 enabling the thermostatic mixing valve to more accurately  
10 maintain the temperature of the water output from the mix  
11 port of the mixing valve. Furthermore a mixing valve is  
12 needed which includes a biasing spring arrangement that  
13 prevents the water from being directed away from the thermal  
14 actuator and does not vibrate, thus eliminating  
15 objectionable noises from the mixing valve during operation.  
16

#### 17 Summary of the Invention

18 Accordingly, the present invention provides an  
19 improved thermostatic mixing valve which facilitates a  
20 thorough mixing of the hot and cold water and which does not  
21 have the noise problem associated with the prior art. The  
22 mixing valve of the present invention includes an extended  
23 mixing chamber, which provides more room for the incoming  
24 hot and cold water to mix before the mixture flows over the  
25 thermal actuator. The mixing valve also includes a diffuser  
26 which is biased against the annular ring of the thermal  
27 actuator by a bias spring, wherein the diffuser acts to  
28 further mix the water flowing from the mixing chamber, while  
29 also directing the water toward the cup of the thermal



1 actuator for more accurate sensing of the water temperature  
2 by the thermal actuator. The biasing spring is shaped and  
3 mounted within the valve in such a way that the water  
4 flowing through the valve is directed away from the bias  
5 spring by the diffuser, thus reducing or eliminating the  
6 noise problem associated with prior art mixing valves.

7 According to one embodiment of the present  
8 invention, a mixing valve is disclosed which receives fluid  
9 from a first source and fluid from a second source and  
10 outputs a mixture of the fluids. The mixing valve comprises  
11 a valve body including a first fluid inlet, a first fluid  
12 chamber in fluid communication with the first fluid inlet,  
13 a second fluid inlet, a second fluid chamber in fluid  
14 communication with the second fluid inlet, a mixing chamber  
15 in fluid communication with the first fluid chamber and the  
16 second fluid chamber and a fluid outlet in fluid  
17 communication with the mixing chamber. The mixing valve  
18 further comprises a fluid flow regulator mounted within the  
19 housing between the first fluid chamber and the second fluid  
20 chamber, wherein a lower surface of the fluid flow regulator  
21 is disposed within the first fluid chamber and an upper  
22 surface of the fluid flow regulator is disposed within the  
23 second fluid chamber. The fluid flow regulator is mounted  
24 within the valve body in such a way as to permit movement  
25 of the fluid flow regulator along a longitudinal axis of the  
26 valve body, the fluid flow regulator having apertures  
27 therein which permit a flow of fluid between the second  
28 fluid chamber and the mixing chamber. The fluid flow  
29 regulator includes a central hub which extends below the

1 lower surface into the mixing chamber. A temperature-  
2 sensing device is mounted to the central hub of the fluid  
3 flow regulator, the temperature-sensing device including a  
4 cup portion disposed proximate the mixing chamber and a  
5 piston which extends through the central hub of the fluid  
6 flow regulator and into engagement with an adjustably fixed  
7 surface of an adjustment device of the mixing valve, the  
8 adjustment device being mounted to the valve body of the  
9 mixing valve. The cup portion is constructed and arranged  
10 for sensing a temperature of fluid which flows from the  
11 mixing chamber to the outlet, causing the piston to extend  
12 from the temperature-sensing device in response to an  
13 increase in temperature and causing the piston to retract  
14 into the temperature-sensing device in response to a  
15 decrease in temperature. A bias spring is mounted between  
16 the valve housing and the temperature-sensing device which  
17 biases the temperature-sensing device against the adjustably  
18 fixed surface of the adjustment device.

19 When the temperature of fluid passing from the  
20 mixing chamber over the cup increases, the temperature-  
21 sensing device moves the fluid flow regulator downward to  
22 limit the flow of fluid from the first fluid chamber to the  
23 mixing chamber and increase the flow of fluid from the  
24 second fluid chamber to the mixing chamber, and when the  
25 temperature of fluid passing from the mixing chamber over  
26 the cup decreases, the temperature-sensing device moves the  
27 fluid flow regulator upward to limit the flow of fluid from  
28 the second fluid chamber to the mixing chamber and increase  
29 the flow of fluid from the first fluid chamber to the mixing

1 chamber, thereby causing fluid flowing from the fluid outlet  
2 to remain close to a preset temperature which is set by the  
3 adjustment device.

4 According to another embodiment of the invention,  
5 a mixing valve is disclosed which receives fluid from a  
6 first source and fluid from a second source and outputs a  
7 mixture of the fluids. The mixing valve comprises a valve  
8 body including a first fluid inlet, a first fluid chamber in  
9 fluid communication with the first fluid inlet, a second  
10 fluid inlet, a second fluid chamber in fluid communication  
11 with the second fluid inlet, a mixing chamber in fluid  
12 communication with the first fluid chamber and the second  
13 fluid chamber and a fluid outlet in fluid communication with  
14 the mixing chamber. The mixing valve further comprises a  
15 fluid flow regulator mounted within the housing between the  
16 first fluid chamber and the second fluid chamber, wherein a  
17 lower surface of the fluid flow regulator is disposed within  
18 the first fluid chamber and an upper surface of the fluid  
19 flow regulator is disposed within the second fluid chamber.  
20 The fluid flow regulator is mounted within the valve body in  
21 such a way as to permit movement of the fluid flow  
22 regulator along a longitudinal axis of the valve body, the  
23 fluid flow regulator having apertures therein which permit  
24 a flow of fluid between the second fluid chamber and the  
25 mixing chamber. A temperature-sensing device is mounted  
26 to a central hub of the fluid flow regulator, the  
27 temperature-sensing device including a cup portion disposed  
28 proximate the mixing chamber and a piston which extends  
29 through the central hub of the fluid flow regulator and into

1 engagement with an adjustably-fixed surface of an adjustment  
2 device of the mixing valve, the adjustment device being  
3 mounted to the valve body of the mixing valve. The cup  
4 portion is constructed and arranged for sensing a  
5 temperature of fluid which flows from the mixing chamber to  
6 the outlet, causing the piston to extend from the  
7 temperature-sensing device in response to an increase in  
8 temperature and causing the piston to retract into the  
9 temperature-sensing device in response to a decrease in  
10 temperature. A bias spring is mounted between the valve  
11 housing and the temperature-sensing device which biases the  
12 temperature-sensing device against the adjustably fixed  
13 surface of the adjustment device. A diffuser is mounted  
14 between the bias spring and an annular ring of the  
15 temperature-sensing device, the diffuser being for agitating  
16 the fluid as it passes from the mixing chamber into contact  
17 with the cup of the temperature-sensing device.

18 When the temperature of fluid passing from the  
19 mixing chamber over the cup increases, the temperature-  
20 sensing device moves the fluid flow regulator downward to  
21 limit the flow of fluid from the first fluid chamber to the  
22 mixing chamber and increase the flow of fluid from the  
23 second fluid chamber to the mixing chamber, and when the  
24 temperature of fluid passing from the mixing chamber over  
25 the cup decreases, the temperature-sensing device moves the  
26 fluid flow regulator upward to limit the flow of fluid from  
27 the second fluid chamber to the mixing chamber and increase  
28 the flow of fluid from the first fluid chamber to the mixing  
29 chamber, thereby causing fluid flowing from the fluid outlet

1 to remain close to a preset temperature which is set by the  
2 adjustment device.

3  
4 Brief Description of the Drawings

5 In the drawings which illustrate the best mode  
6 presently contemplated for carrying out the present  
7 invention:

8 Fig. 1 is a sectional view of a prior art mixing  
9 valve;

10 Fig. 2 is a sectional view of the mixing valve of  
11 the present invention;

12 Fig. 3 is a top view of a first embodiment of a  
13 diffuser used in conjunction with the mixing valve of the  
14 present invention;

15 Fig. 4 is a cross-sectional view of the diffuser  
16 of Fig. 3, taken along line 4-4 in Fig. 3;

17 Fig. 5 is a top view of a second embodiment of a  
18 diffuser used in conjunction with the mixing valve of the  
19 present invention; and

20 Fig. 6 is a cross-sectional view of the diffuser  
21 of Fig. 5, taken along line 6-6 in Fig. 5.

22  
23 Description of the Invention

24 Referring now to Figs. 2-6, an improved  
25 thermostatic mixing valve of the present invention will be  
26 described. As shown in Fig. 2, a mixing valve 100 includes  
27 a body 112, a thermal actuator 114, a spool 116, a biasing  
28 spring 118, a body cover 120 and a temperature selection  
29 device 122. The body 112 incorporates a hot port, made up

1 of an external hot port 124a and an internal hot port 124b,  
2 a cold port, made up of an external cold port 126a and an  
3 internal cold port 126b, and a mix port 128. Body 112 also  
4 includes a hot annular groove 156 and a cold annular  
5 groove 158. The body 112 is typically formed from forged  
6 or cast metal.

7 The spool 116 is located between surface A of the  
8 body 112 and surface B of the body cover 120. Similar to  
9 the mixing valve 10 of Fig. 1, the distance between surface  
10 A of the body 112 and surface B of the body cover 120 is  
11 greater than the length  $l$  of spool 116. The difference in  
12 the distance between surface A of body 112 and surface B of  
13 body cover 120 and the spool length  $l$  is referred to as the  
14 spool stroke, which is the distance that the spool 116 can  
15 travel between the surface A of body 112 and surface B of  
16 body cover 120. Spool 116 includes an annular cold water  
17 chamber 134 and is supported and frictionally engaged within  
18 body 112 by O-ring seal 136. Spool 116 also includes  
19 external hub 200 which extends from the bottom surface 220  
20 of spool 116.

21 Thermal actuator 114 is an elongated version  
22 of the thermal actuator 14, having a longer piston 130 and  
23 a longer and narrower cup 132 than the piston 30 and cup 32,  
24 respectively of the thermal actuator 14. However, while  
25 being shaped differently from thermal actuator 14, thermal  
26 actuator 114 operates identically to thermal actuator 14 as  
27 described above. As stated above, thermal actuator 114  
28 includes an actuator piston 130, which is biased against  
29 head 152 of spindle 140. Thermal actuator 114 is

1 threadably coupled to spool 116 at region 200a within  
2 external hub 200 of spool 116, such that actuator piston 130  
3 is centrally disposed within spool 116 and such that the  
4 actuator piston 130 travels in a direction along the  
5 longitudinal axis 146 of the spool 116.

6 A mixing chamber 160 is formed between the bottom  
7 of spool 116 and an annular ring 162, which is part of  
8 cup 132 of thermal actuator 114. The configuration of the  
9 external hub 200 enables the thermal actuator 114 to be  
10 positioned further downstream from surface A of the  
11 body 112, thereby substantially increasing the length of the  
12 mixing chamber 160, as compared to the prior art device.  
13 This increase in the length of the mixing chamber 160  
14 provides more space for the hot and cold water to mix before  
15 the mixture passes over the cup 132 of the thermal  
16 actuator 114, thus enabling a more thorough mix of the hot  
17 and cold water, as compared to the prior art device.

18 A diffuser 202 is biased against annular ring 162  
19 by bias spring 118, which has its other end engaged by a  
20 lip 206 of body 112. Diffuser 202 is shown in greater  
21 detail in Fig. 3, which is a top view of the diffuser 202  
22 and Fig. 4, which is a cross-sectional view of the  
23 diffuser 202, taken along line 4-4 in Fig. 3. As can be  
24 seen in Figs. 2- 4, diffuser 202 includes a peripheral  
25 wall 210, a number of fins 212 projecting inwardly from the  
26 peripheral wall 210 toward the center of the diffuser 202,  
27 and an annular plate 214 projecting inwardly from the  
28 peripheral wall 210 to form an aperture 216. Aperture 216  
29 has a diameter which is slightly larger than the outside

1 diameter of the cup 132. Preferably, the diffuser is formed  
2 from a mixture of polypropylene and fiberglass, however, it  
3 will be understood that the diffuser 202 may be formed from  
4 any suitable material. Also, diffuser 202 may be formed  
5 from a single piece of material, or the peripheral wall 210  
6 and fins 212 may be formed separately from the annular  
7 plate 214 and then mounted onto the thermal actuator 114.

8 An alternative embodiment of the diffuser is  
9 shown at 302 in Fig. 5, which is a top view of the  
10 diffuser 302, and Fig. 6, which is a cross-sectional view  
11 of the diffuser 302, taken along line 6-6 in Fig. 5. The  
12 diffuser 302 includes a peripheral wall 310, a number of  
13 fins 312 projecting inwardly from the peripheral wall 310  
14 toward the center of the diffuser 302, and an annular  
15 plate 314 projecting inwardly from the peripheral wall 310  
16 to form an aperture 316. Aperture 316 has a diameter which  
17 is slightly larger than the outside diameter of the cup 132.

18 The operation of the mixing valve 100 will now be  
19 described. The operation of the temperature selection  
20 device 122 is identical to that described with reference to  
21 the temperature selection device 22 of Fig. 1, and therefore  
22 will not be described with reference to the mixing  
23 valve 100.

24 Hot water enters the body 112 through the  
25 external hot port 124a, as shown by dashed lines 180, fills  
26 the hot annular distribution groove 156, and then flows  
27 radially inward through the internal hot port 124b into the  
28 mixing chamber 160. Cold water enters the body 112 through  
29 the external cold port 126a, as shown by dotted dashed



lines 182, fills the cold annular distribution groove 158, flows radially inward through the internal cold port 126b into the annular cold water chamber 134 and then flows through a series of holes 220 located in the spool 116 into the mixing chamber 160. Due to the increased size of mixing chamber 160, hot and cold water are allowed more volume and time to blend in the mixing chamber 160, thus creating a more thorough and uniform mix. This mixed water then flows through diffuser 202, which preferably imparts rotation to the flow, thereby causing the flow of water to rotate around the cup 132, further agitating and mixing the water. However, it is not essential for the flow to rotate to provide the increased mixing feature of the diffuser 202. For example, while lower water pressures may not result in the rotation of the flow of water, the water passing through the diffuser 202 will still be more thoroughly mixed and agitated than it would in the absence of diffuser 202. Also, the diffuser shown in Figs. 5 and 6 is less likely to cause the flow of water to rotate than the diffuser shown in Figs. 3 and 4.

As can be seen in Fig. 2, the diffuser 202 also acts to pull the water toward cup 132 by forcing the water through the aperture 216 in annular plate 214, thus allowing a more accurate sensing of the true average temperature of the mixed water. Furthermore, due to the orientation of bias spring 118, which is inverse from that in the prior art device, the mixed water 184 flows through the diffuser 202 and is discharged from valve 100 through mix port 128 without having to pass through the coils of bias spring 118,

1 thereby eliminating the noise problem associated with the  
2 prior art mixing valve.

3 The operation of the spool 116 and thermal  
4 actuator 114 is similar to the operation of the spool 16 and  
5 thermal actuator 14 described above. Specifically, if the  
6 temperature of the cold water supply decreases such that the  
7 thermal expansion material within cup 132 of thermal  
8 actuator expands, actuator piston 130 is pushed outwardly  
9 from thermal actuator 114 against head 152 of spindle 140.  
10 This causes thermal actuator 114 to pull spool 116 away from  
11 surface B of body cover 120 and toward surface A of  
12 body 112. As spool 116 is pulled toward surface A, the  
13 width of the internal hot port 124b decreases, thereby  
14 decreasing the amount of hot water which is allowed to pass  
15 into mixing chamber 160. At the same time, as spool 116 is  
16 pulled away from surface B, the width of the internal cold  
17 port 126b increases, thereby increasing the amount of cold  
18 water which is allowed to pass through annular cold water  
19 chamber 134 and into mixing chamber 160. The resulting mix  
20 of water discharged through mix port 128 therefore has a  
21 temperature which is closer to the desired temperature set  
22 by the temperature selection device. As the temperature of  
23 the mixed water decreases, the thermal expansion material  
24 contracts, causing actuator piston 130 to recede into the  
25 thermal actuator 114. Bias spring 118 then forces thermal  
26 actuator 114 and spool 116 toward surface B, thereby  
27 allowing internal hot port 124b and internal cold port 126b  
28 to return to their steady-state positions.

1 If the temperature of the hot water supply  
2 decreases, the opposite action occurs in thermal  
3 actuator 114 and, as piston 130 retracts into the thermal  
4 actuator 114, spool 116 is pushed toward surface B by bias  
5 spring 118. This causes the width of the internal hot  
6 port 124b to increase, thereby increasing the amount of hot  
7 water which is allowed to pass into mixing chamber 160. At  
8 the same time, as spool 116 is pushed toward surface B, the  
9 width of the internal cold port 126b decreases, thereby  
10 decreasing the amount of cold water which is allowed to pass  
11 through annular cold water chamber 134 and into mixing  
12 chamber 160. The resulting mix of water discharged through  
13 mix port 128 therefore has a temperature which is closer to  
14 the desired temperature set by the temperature selection  
15 device.

16 A characteristic of thermostatic mixing valves is  
17 that when water is first drawn, either after a long period  
18 of no draws (i.e., overnight) or even shortly after a  
19 previous draw, the mix water temperature momentarily  
20 overshoots the set temperature. The reason for the  
21 overshoot is that as soon as the flow of water ceases, the  
22 thermal actuator starts to cool down. However, since the  
23 thermal actuator is trying to maintain the set temperature,  
24 it is looking for more hot water and less cold water.  
25 Accordingly, the width of the hot water port is increased  
26 and the width of the cold water port is decreased relative  
27 to a steady state condition. When the demand for water is  
28 then received, the hot and cold water enters the valve with  
29 the spool in a position that allows too much hot water and

1 too little cold water to pass, thus resulting in a mix  
2 temperature higher than that which is set by the temperature  
3 selection device. This is a momentary condition which  
4 begins to correct itself as soon as the mix water contacts  
5 the thermal element. Since the thermal element reacts to  
6 the increased water temperature by reducing the width of the  
7 hot water port while increasing the width of the cold water  
8 port, the mix temperature quickly reverts to the desired  
9 level.

10 It has been found that both the magnitude of the  
11 temperature overshoot and the duration of the overshoot are  
12 significantly decreased with the valve of the present  
13 invention as compared to the prior art valve described with  
14 reference to Fig. 1. This represents a huge safety  
15 advantage. In fact, tests have shown that in the present  
16 invention, the magnitude and duration of the temperature  
17 overshoot is reduced by approximately 50%.

18 In summary, it can be seen that the present  
19 invention provides a thermostatic mixing valve which  
20 facilitates the mixing of the cold and hot water before the  
21 water passes over the cup of the thermal actuator, thus  
22 allowing the thermal actuator to more accurately react to  
23 the temperature of the mixture, thus enabling the  
24 thermostatic mixing valve to more accurately maintain the  
25 temperature of the water output from the mix port of the  
26 mixing valve. Furthermore the mixing valve includes a  
27 biasing spring arrangement that prevents the water from  
28 being directed away from the thermal actuator and does not

1 vibrate, thus eliminating objectionable noises from the  
2 mixing valve during operation.

3 While there is shown and described herein certain  
4 specific structure embodying the invention, it will be  
5 manifest to those skilled in the art that various  
6 modifications and rearrangements of the parts may be made  
7 without departing from the spirit and scope of the  
8 underlying inventive concept and that the same is not  
9 limited to the particular forms herein shown and described.